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(54) Vehicle mounted a.c. generator.

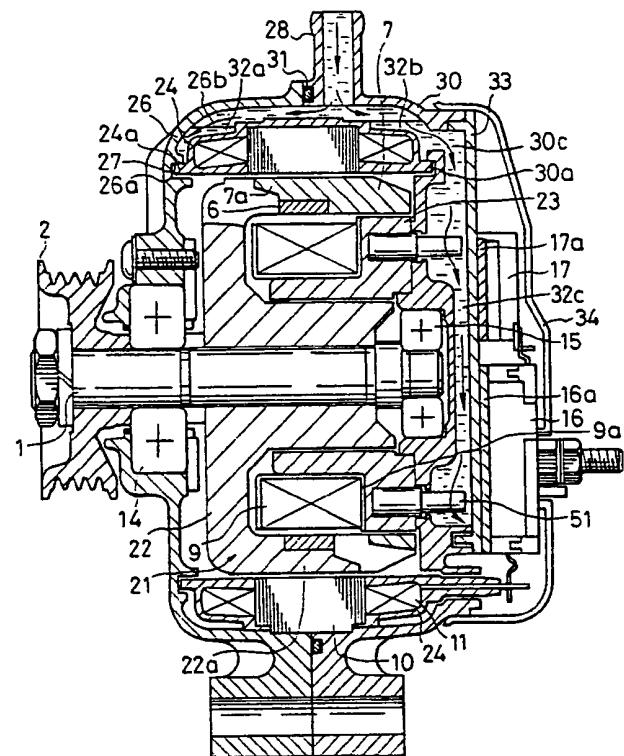
(57) A vehicle mounted a.c. generator includes an annular coolant passage (32a) around a stator coil (11) thereof and a branch coolant passage (32c) extending from an inlet portion of said annular coolant passage (32a) to a return portion of the latter. A fan cooler may be provided in a front bracket (26) of

the generator, additionally.

High thermal conductive members (51) coupled to a stationary core (23) extend therefrom through a rear bracket (30) into the branch coolant passage (32c).

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FIG. 6



**BACKGROUND OF THE INVENTION**

The present invention relates to a vehicle mounted a.c. generator adapted to be driven by an engine of the vehicle and, particularly, to an improvement of a cooling system thereof.

A cross section of a conventional vehicle mounted a.c. generator is shown in Fig. 1, in which a pulley 2 and a rotor 3 are secured to a rotary shaft 1 and the rotor 3 is composed of a rotor core 4 mounted on the shaft 1, a magnetic pole member 5 having a plurality of angularly spaced nails 5a formed peripherally thereof, a support ring 6 of non-magnetic material fixedly secured to an inner periphery of the nails 5a and an opposite magnetic pole member 7 fixedly secured to the support ring 6 and having a plurality of angularly spaced nails 7a which are interleaved with the nails 5a. A stationary exciting core 8 is arranged between the core 4 and the member 7 with air gaps with respect to the rotor core 4 and the opposite pole member 7 to support an exciting coil 9.

The generator further includes a stator core 10 which supports a stator coil 11 in slots thereof, a front bracket 12 supports the shaft 1 through a bearing 14, an outlet hole 12a formed in the bracket 12, a rear bracket 13 for supporting, together with the front bracket 12, the stator core 10 and the shaft 1 through a bearing 15. The bracket 13 also supports the core 8 fixedly and has an inlet port 13a for cooling air. A rectifier 16 functions to convert an a.c. power produced in the stator coil 11 into a d.c. power. A voltage regulator 17 detects a generator voltage to control an exciting current to thereby regulate a terminal voltage to a predetermined value and a fan 18 is fixed to the shaft 1.

In the conventional a.c. generator constructed as above, the shaft 1 is rotated by the engine rotation through a belt and the pulley 2. Upon the rotation of the shaft 1, an a.c. voltage is induced in the stator coil 11 which is rectified by the rectifier 16 and regulated by the voltage regulator 17, a resultant d.c. voltage being supplied to the exciting coil 9 and to a load such as a battery.

A cooling air sucked through the inlet port 13a of the rear bracket 13 by a rotation of the fan 18 fixed to the shaft 1 cools an interior of the generator and is discharged through the outlet port 12a of the front bracket 12.

In such generator, heat generated by the exciting coil 9, the stator coil 11, the bearings 14 and 15 and the voltage regulator 16 housed in the bracket 13 is discharged by the air flow mentioned above. However, it is usually insufficient to cool the inside of the bracket 13 by means of the fan 18. In order to obtain a sufficient cooling effect it is possible to use a larger fan. However, with such large fan, there may be a large noise produced. Further,

since air to be used to cool the generator tends to degrade insulations of various portions thereof, the use of air coolant passing through the inside of the generator should be minimized. In addition thereto, a power required to drive such large fan becomes considerable.

**SUMMARY OF THE INVENTION**

10 A primary object of the present invention is to provide a vehicle mounted a.c. generator which can restrict noise to a minimum level while providing a sufficient cooling effect.

15 Another object of the present invention is to provide a vehicle mounted a.c. generator having a simplified cooling system with a minimized noise and minimized power loss.

20 In order to achieve these objects, a vehicle mounted a.c. generator according to the present invention is provided with cooling passages extending along an outer periphery of the stator coil and along other portions of the generator in which large heat is generated, through which a liquid coolant circulates. The liquid coolant may be a portion of an engine coolant.

**BRIEF DESCRIPTION OF THE DRAWINGS**

30 Fig. 1 is a cross section of a conventional vehicle mounted a.c. generator;  
Fig. 2 is a cross section of an embodiment of the present invention;  
Fig. 3 is a partially cut away front view of a main portion of the embodiment shown in Fig. 2;  
Fig. 4 is a cross section of another embodiment of the present invention;  
Figs. 5, 6 and 7 are cross sections of other embodiments of the present invention respectively;  
40 Figs. 8 and 9 are partially cut away front views of other embodiments of the present invention, respectively;  
Figs. 10 and 11 are cross sections of other embodiments of the present invention, respectively;  
Fig. 12 is a cross section of another embodiment of the present invention;  
Fig. 13 is an enlarged view of a main portion of the embodiment shown in Fig. 12;  
50 Figs. 14 and 15 are cross sections of other embodiments of the present invention, respectively; and  
Fig. 16 is a partially cutaway front view of the embodiment shown in Fig. 15.

**DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS**

In Figs. 2 and 3, reference numerals 1, 2, 6, 7, 7a, 9-11 and 14-17 depict the same components as those of the conventional generator shown in Fig. 1, respectively, and therefore descriptions of these components are omitted for avoidance of duplication. A reference numeral 21 depicts a rotor composed of a magnetic pole member 22 fixedly secured to a shaft 1 and having a plurality of angularly spaced nails 22a provided on a periphery thereof which are interleaved with nails 7a of an opposite magnetic pole member 7.

A stationary exciting core 23 is arranged between the magnetic pole member 22 and the opposite magnetic pole member 7 with air gaps therebetween and supports an exciting coil 9. An enclosure 24 formed of a metal such as aluminum having a high thermal conductivity encloses a cylindrical stator coil 11. An insulating filler 25 such as synthetic resin fills spaces between it and the opposite end portions of the stator coil 11 to provide a liquid-tight connection to the stator core 10 and thereby protect the stator coil against the liquid coolant. A plurality of heat radiating fins 24b are formed in opposite end portions of an inner wall of the enclosure 24 circumferentially, as shown in Fig. 3.

A front bracket 26 supports the stator core 10 and is formed on an inner surface thereof with an annular groove 26a in which the fins 24a of one end portion of the enclosure 24 fit liquid-tightly with an aid of a gasket 27 of a material such as viscose silicon compound to form a pair of annular coolant passages 32a extending peripherally thereof between the enclosure 24 and the inner wall of the bracket 26. The front bracket 26 is provided with a coolant inlet pipe 28 and a coolant outlet pipe 29 between which a partition 26b is provided. A tube 35 is connected to the coolant inlet pipe 28 to supply a portion of the engine coolant from an outgoing portion of an engine cooling system and a tube 36 is connected to the outlet pipe 29 to return the coolant to the cooling system. A reference numeral 30 depicts a rear bracket to be fixedly secured through an O-ring 31 to the front bracket 26 which is formed on an inner surface thereof with a groove 30a in which the fins 24a of the other end portion of the enclosure 24 fits liquid-tightly with an aid of a viscose gasket 27. The rear bracket 30 fixedly supports the core 23 and the bearing 15. The bracket 30 is formed with a coolant branch inlet port 30c and a return port 30d. A coolant passage 32b is formed between the inner wall of the rear bracket 30 and an outer surface of the enclosure 24 and a partition 30b is also formed to separate the incoming side from the outgoing side.

A cooling cover 33 of a metal having a good thermal conductivity is liquid-tightly mounted on an outer end portion of the rear bracket 30, between

which a branch passage 32c is formed through which the coolant from the branch port 30c flows. The coolant is then returned through the return port 30d to the passage 32b. A plurality of heat radiating fins 33a are arranged on an inner surface of the cooling cover 33 along the flowing direction of the coolant. A rectifier 16 is fixedly secured through a heat sink 16a to an outer end surface of the cooling cover 33 and a voltage regulator 17 is also secured through a heat sink 17b thereto. A reference numeral 34 depicts a protection cover mounted to the rear bracket 30.

A cooling effect obtained by the cooling system mentioned above will be described. A portion of the coolant of the vehicle engine, which is relatively low temperature, is used for cooling the generator. The coolant portion flows from the inlet pipe 28 through the passages 32a and 32b as shown by arrows to cool the stator core 10 and the stator coil 11. The coolant whose temperature is risen thereby is discharged through the outlet pipe 29 to the return path of the engine coolant circulation system.

A portion of the coolant flown through the inlet pipe 28 into the passage 32b passes through the branch port 30b and the branch passage 32c to cool the rectifier 16 and the voltage regulator 17 indirectly through the cooling cover 33 and then returned to the passage 32b as shown by arrows.

The front bracket 30 which is cooled directly by the coolant absorbs heat generated in the bearing 14 and the rear bracket 30 which is also cooled directly absorbs heat generated in the bearing 15 and in the exciting coil 9 through the core 23.

The plurality of heat radiating fins 24b provided on the respective end portions of the enclosure 24 and the plurality of heat radiating fins 33a provided on the cooling cover 33 increase the heat exchange effect and hence the cooling effect.

It may be possible to use a separate coolant circulation system instead of the cooling passage from the passage 32b through the branch passage 32c.

Thus, the stator coil 11, the rectifier 16, the voltage regulator 17 and the energizing coil 9 which produce large heat are cooled effectively, so that temperatures thereof are restricted substantially without using fan cooler which is a source of noise.

Fig. 4 shows a second embodiment of the present invention in which components shown by the same reference numerals as used in Figs. 2 and 3 are the same components as those in the first embodiment. A rotor 41 is composed of one and the opposite pole cores 42 and 43 fixedly secured to a rotor shaft 1 and an exciting coil 9 supported thereby. A plurality of nails 42a protruding from the pole core 42 are interleaved with a plurality

nails 43a protruding from the core 43 as in the first embodiment. A brush device 45 supplies electric power to slip-rings 44 connected to the exciting coil 9. A cooling cover 46 is liquid-tightly mounted to a rear bracket 30 to form a branch passage 32c therebetween and a rectifier 16 and a voltage regulator 17 are mounted on a cooling cover 46. A reference numeral 47 depicts a protection cover.

The front and rear brackets 26 and 30 are directly cooled by the coolant and inside air cooled by these brackets is agitated by rotation of the rotor 41 to cool the exciting coil 9 effectively.

In the embodiment shown in Figs. 2 and 3, the stator coil 11 is covered by the enclosure 24 of the good thermal conductive material and the enclosure is filled with the resin. In a third embodiment shown in Fig. 5, however, a stator coil 11 is enclosed directly by an insulating synthetic resin mold and supported liquid-tightly by a front and a rear bracket 26 and 30 so that coolant passages 32a and 32b are formed.

Fig. 6 shows a fourth embodiment of the present invention in which one end of a good thermal conductive member 51 is thermally coupled to a stationary core 23 and the other end thereof protrudes into a branch passage 32c formed between a rear bracket 30 and a cooling cover 33. With this construction, a coolant flowing through the branch passage 32c cools a rectifier 16 and a voltage regulator 17 indirectly through the cooling cover 33 and a bearing 15 and the core 23 indirectly through a front bracket 26. Further, the core 23 and an exciting coil 9 are cooled by the thermally conductive member 51.

Fig. 7 is a fifth embodiment of the present invention which differs from the fourth embodiment in Fig. 6 in that a plurality of heat radiating fins 51a in the form of flanges are formed on the protruded portion of the thermally conductive member 51, that a bobbin 9a of the exciting coil 9 is formed of a good thermal conductivity material and that an end portion of the thermally conductive member 51 is pressure-contacted to the bobbin 9a to obtain a good thermal coupling therebetween. With such construction of the fifth embodiment, the cooling of the exciting coil 9 becomes more effective.

It may be possible to use the so-called heat pipe composed of a metal pipe filled with a coolant which evaporates with heat and liquefied when cooled, as the thermally conductive member 51.

Figs. 8 and 9 show a sixth embodiment of the present invention. In the sixth embodiment, a stationary core 23 is provided in an outer end surface thereof with a blind hole 23a and a rear bracket 30 is provided with blind holes 30f and 30g. Pipes 52 and 53 are inserted thereinto, into which a portion of a coolant flowing through a passage 32c is introduced to cool the core 23 and a bearing 15

peripherally.

It is possible to construct the generator such that bearings 14 and 15 supported by a front and rear brackets 26 and 30 are cooled by a coolant as shown in Figs. 10 and 11. In Figs. 10 and 11 which show a seventh and eighth embodiments, respectively, an end portion of an enclosure 24 enclosing a stator coil 11 is elongated axially to engage with an outer peripheral end surface of the bearing 14 and the front bracket 26 is formed in an area thereof surrounding the bearing 14 with an annular recess 26a. Further, the rear bracket 30 is formed with an annular recess 30a to receive the other end of the enclosure 24 and another annular recess 30e. The coolant is introduced into the recesses 26a and 30e to cool the bearings 14 and 15.

Fig. 12 shows a ninth embodiment of the present invention which further includes a fan cooling system in addition to the liquid coolant system.

In Fig. 12, a rear bracket 30 is provided with a coolant inlet pipe 28 and a coolant outlet pipe 29 and a coolant passage 32a is formed to pass a coolant through an area of a stator coil 11 faced to the rear bracket 30. Further, a branch passage 32c for cooling a rectifier 16 and a voltage regulator 17 is also formed. The above mentioned portion of the construction of the embodiment shown in Fig. 12 is the same as that of the embodiment shown in Figs. 2 and 3.

In the embodiment in Fig. 12, the front bracket 26 is formed in an area surrounding the bearing 14 with air intake holes 26a and in a peripheral area with air discharge holes 26b. A fan 60 is provided on a front end surface of a magnetic pole core 22. The fan 60 is composed of a generally hexagonal plate having six extensions which are bent at right angle to form fins 60a as shown in Fig. 13. Each of the fins 60a is slanted at sweepback angle with respect to a direction A of rotation thereof.

In operation, the fan 60 is rotated with a rotation of the rotor shaft 1 driven by the vehicle engine through the belt and pulley 2 to take air through the intake holes 26a into an interior of the front bracket 26. The cooling air cools the bearing 14 and a front end portion of the stator coil 11 and is discharged through the discharge holes 26b.

On the other hand, a portion of a low temperature liquid coolant for the vehicle engine is branched and introduced through the inlet pipe 28 into the passage 32b as shown by an arrow to cool the rear side end of the stator coil 11 and then discharged through the outlet pipe 29 to the return path of the engine coolant circulation system.

A portion of the coolant introduced through the inlet pipe 28 into the passage 32b flows through a branch port 30c to the branch passage 32c to indirectly cool the rectifier 16 and the voltage regulator 17 through the cooling cover 33 and then

returned to the passage 32b.

The rear bracket 30 which is directly cooled by the liquid coolant cools the bearing 15 and the exciting coil 9 through the stationary core 23.

A speed vector of the cooling air passed through the fin 60a of the fan 60 is  $V_r$  with respect to a rotary coordinate system fixed to the fan 60 as shown in Fig. 13. However, the vector of the cooling air leaving the fan 60 becomes  $V$  since a relative speed vector  $V_v$  with respect to an inertia coordinate system is added as shown in Fig. 13. With the fan construction shown in Fig. 12, an absolute speed  $V$  of the cooling air is very large, so that the cooling effect of the stator coil 11 becomes several times that of the conventional fan. Therefore, the fan 60 can be small in size comparing with the fan 18 shown in Fig. 1 so long as it is to be expected to obtain the same cooling effect. With such small size fan, the noise is very small and a higher speed operation of the fan is achieved without difficulty, while providing a sufficient cooling effect.

Thus, the stator coil 11, the rectifier 16, the voltage regulator 17 and the exciting coil 9 which are large heat generators of the a.c. generator are effectively cooled by the air coolant and the liquid coolant.

Fig. 14 shows a tenth embodiment of the present invention in which an energizing core 42 supports the energizing coil 9 of the embodiment in Fig. 12.

Figs. 15 and 16 show an eleventh embodiment of the present invention. In this embodiment, a cooling pipe 70 connected to an inlet pipe 28 is arranged in around an end wall of a rear bracket 30 and a cooling pipe 71 connected to an outlet pipe 29 is arranged in around a side wall of the rear bracket 30, through which a cooling liquid is circulated to cool a stator coil 11, a bearing 15, a rectifier 16 and a voltage regulator 17.

As described hereinbefore, according to the present invention, the noise and energy loss due to the use of the cooling fan can be at least minimized while increasing the cooling efficiency of the generator. Further, since the generator is liquid-tightly sealed, it is possible to avoid the problems of insulation degradation due to atmosphere and other damages due to toxic gas or salt damages.

### Claims

1. A vehicle mounted a.c. generator, comprising: a rotor shaft (1) adapted to be driven by a vehicle engine; a rotor core (4) fixedly secured to said rotor shaft (1); an exciting coil (9) arranged oppositely to an inner periphery of said rotor (1) for exciting; said rotor armature; a stationary core (23) for supporting said exciting

coil (9); a stator core (10) arranged oppositely to an outer periphery of said rotor core (4) and mounting a stator coil (11) thereon; a front bracket (26) for supporting one end of said stator core (11) directly and said rotor shaft (1) indirectly through a bearing (14); a rear bracket (30) for supporting the other end of said stator core (11) directly and said rotor shaft (1) indirectly through a bearing (15), said stationary core (23) being fixedly secured to said rear bracket (30); a cooling cover (33) for covering a side end surface of said rear bracket (30) to form, together with said rear bracket (30), a branch coolant passage (32c); a rectifier (16) mounted to an outer periphery of said cooling cover (33); a voltage regulator (17) mounted to said outer periphery of said cooling cover (33); high thermal conductive members (51) coupled to said stationary core (23) and extending therefrom through said rear bracket (30) into said branch coolant passage (32c); an annular coolant passage (32a) formed between said stator coil (11) and said brackets (26, 30) for cooling said stator coil (11); said first cooling passage being for cooling said rectifier, said voltage regulator (17) and said exciting coil (9).

2. The vehicle mounted a.c. generator as claimed in claim 1, wherein said high thermal conductive members (51) are pressure contacted at one end thereof to a bobbin (9a) of said exciting coil (9).
3. The vehicle mounted a.c. generator as claimed in claim 1, wherein a portion of each of said high thermal conductive members (51) in said branch coolant passage (32c) is formed with a plurality of heat radiating fins (51a).
4. The vehicle mounted a.c. generator as claimed in claim 1, wherein each of said high thermal conductive members (51) comprises a heat pipe.
5. A vehicle mounted a.c. generator, comprising: a rotor shaft (1) adapted to be driven by a vehicle engine; a rotor core (4) fixedly secured to said rotor shaft (1); an exciting coil (9) arranged oppositely to an inner periphery of said rotor core (4) for exciting said rotor armature; a stationary core (23) for supporting said energizing coil (9); a stator core (10) arranged oppositely to an outer periphery of said rotor core (4) and with a stator coil (11) mounted thereon; a front bracket (26) for supporting one end of said stator core (10) directly and said rotor shaft (1) indirectly through a bearing (14); a rear bracket (30) for supporting the

other end of said stator core (10) directly and  
said rotor shaft (1) indirectly through a bearing  
(15), said stationary core (23) being fixedly  
secured to said rear bracket (30); a cooling  
cover (33) for covering an end surface of said  
rear bracket (30) to form, together with said  
rear bracket (30), a branch coolant passage  
(32c) for cooling a rectifier (16) and a voltage  
regulator (17) mounted on said rear bracket  
(30) and said exciting coil (9); a coolant pas-  
sage (23a) formed in said stationary core (23)  
and extending through said rear bracket (30) to  
said branch coolant passage (32c); and an  
annular coolant passage (32a) formed between  
said stator coil (11) and said brackets (26, 30)  
for cooling said stator coil (11).

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FIG. 1  
PRIOR ART

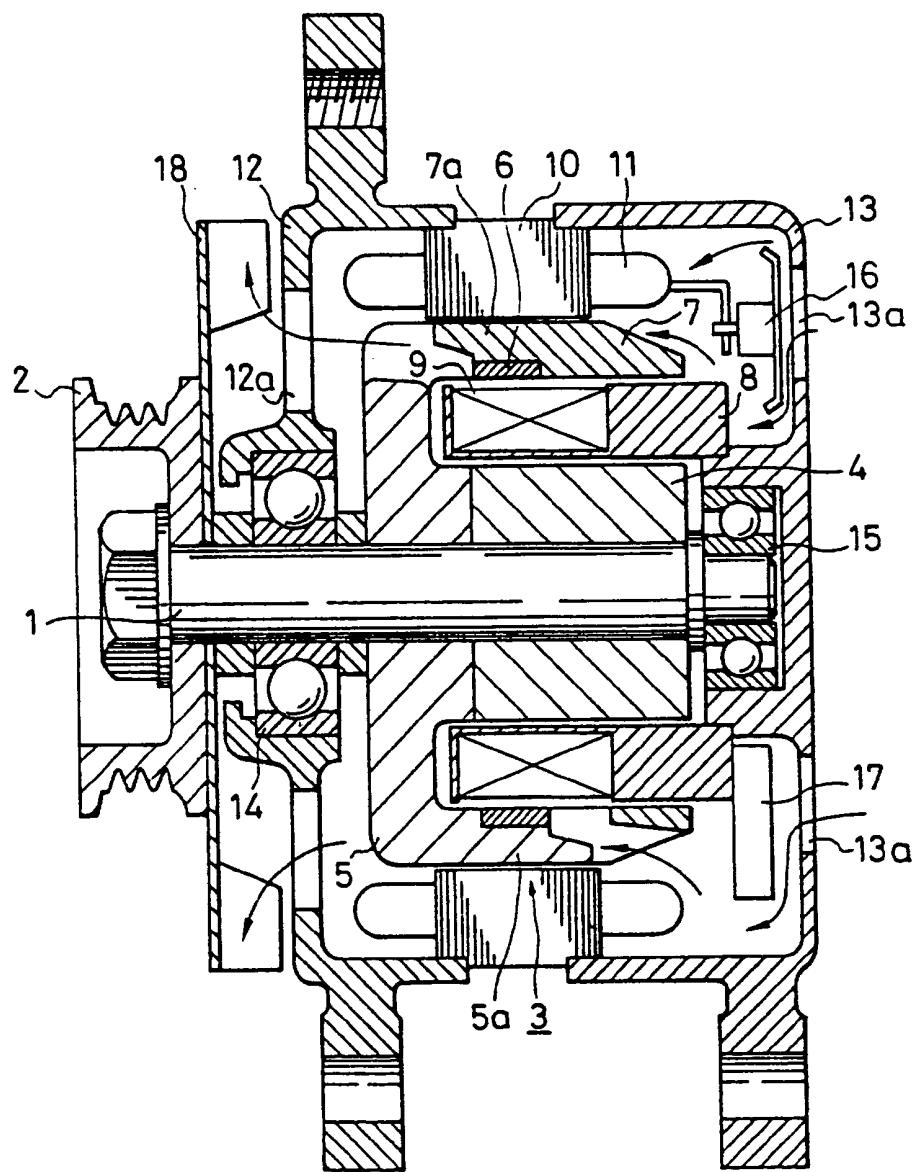


FIG. 2

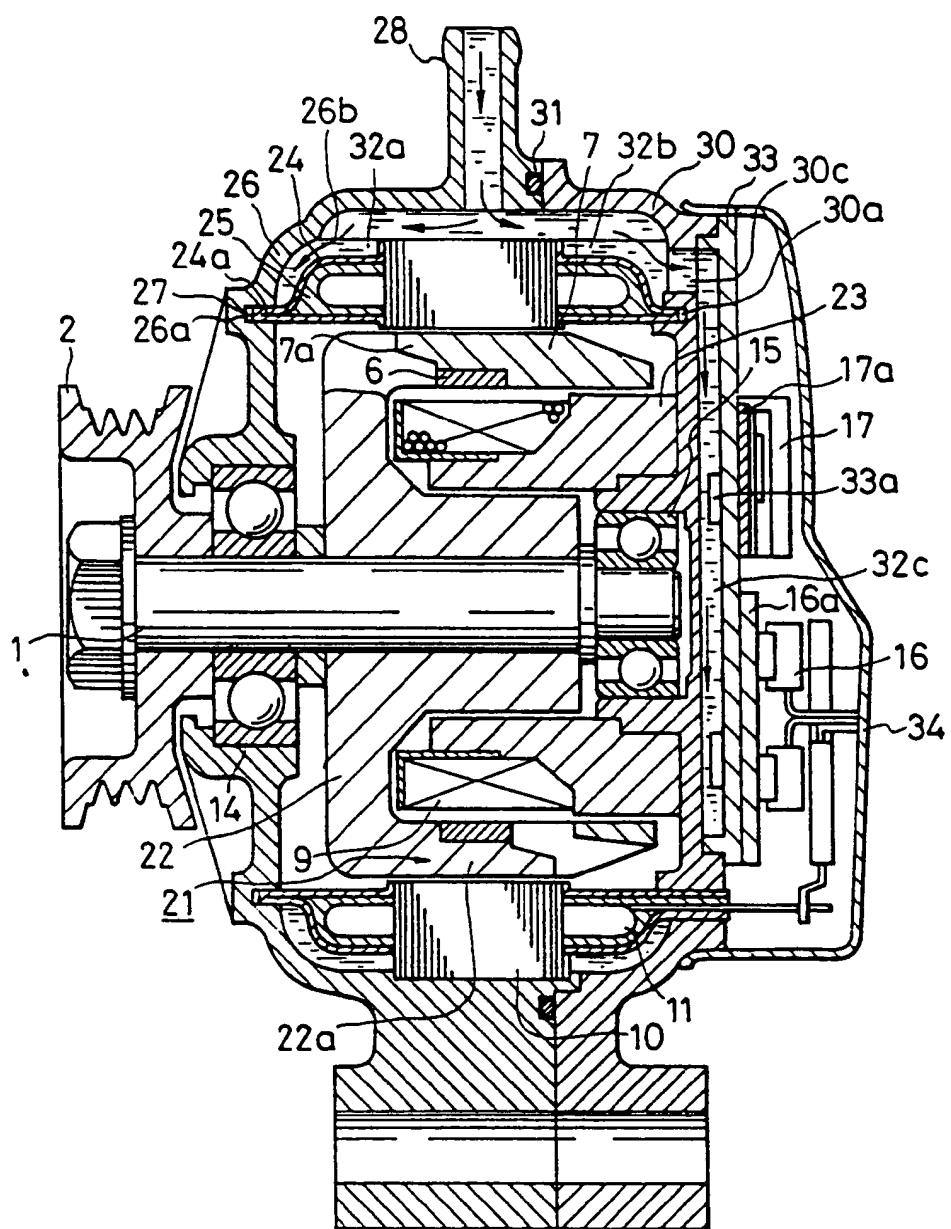


FIG. 3

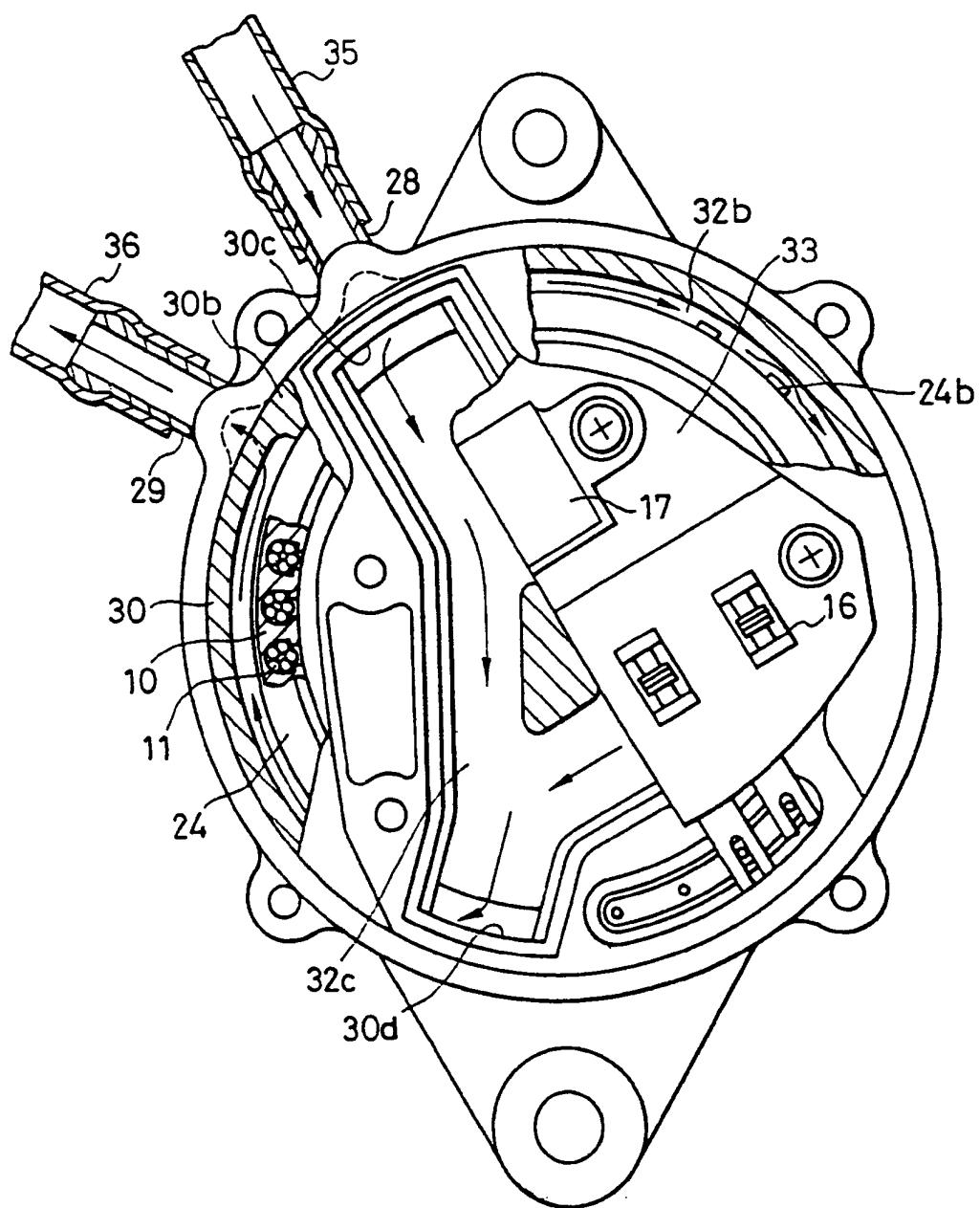


FIG. 4

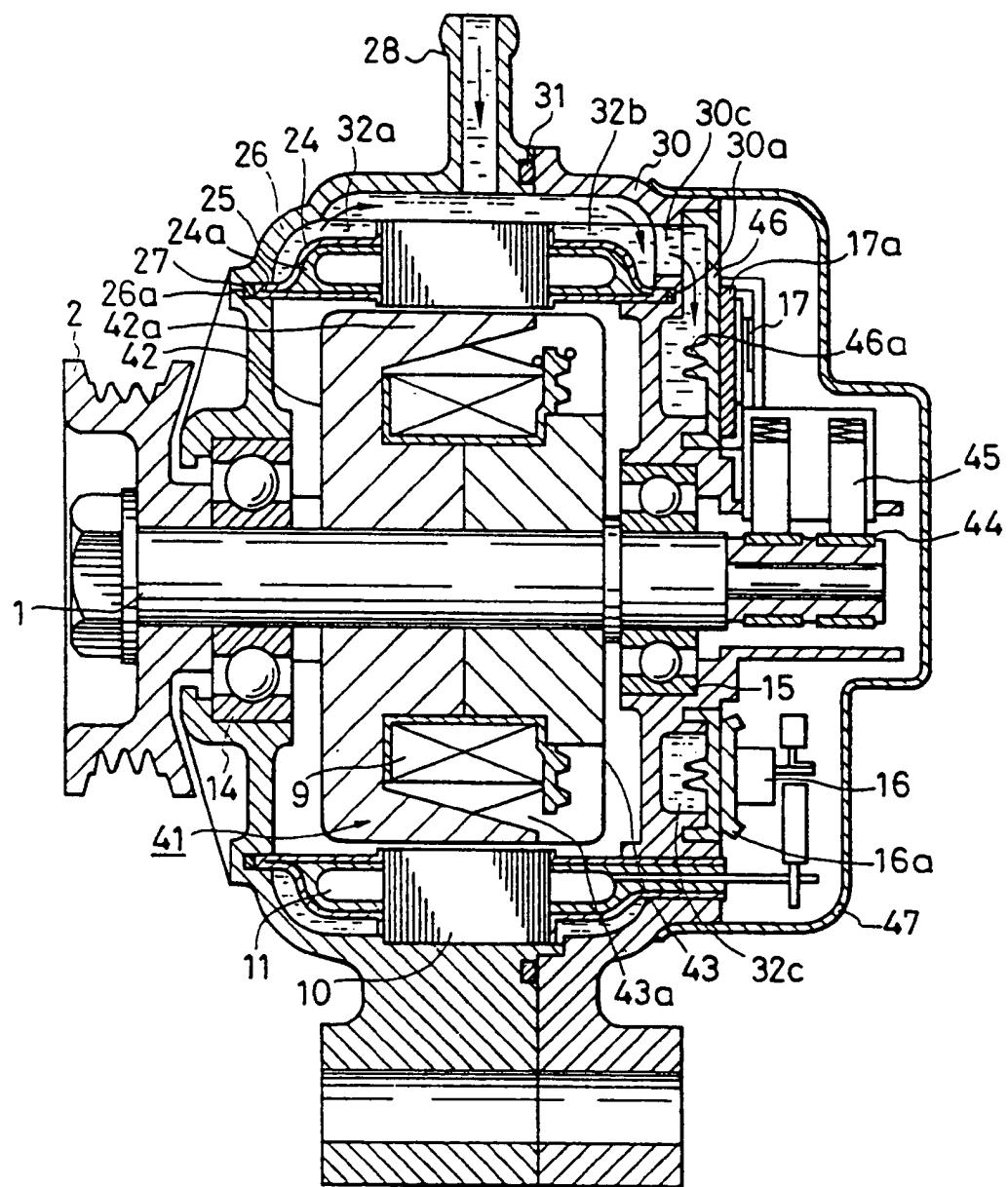


FIG. 5

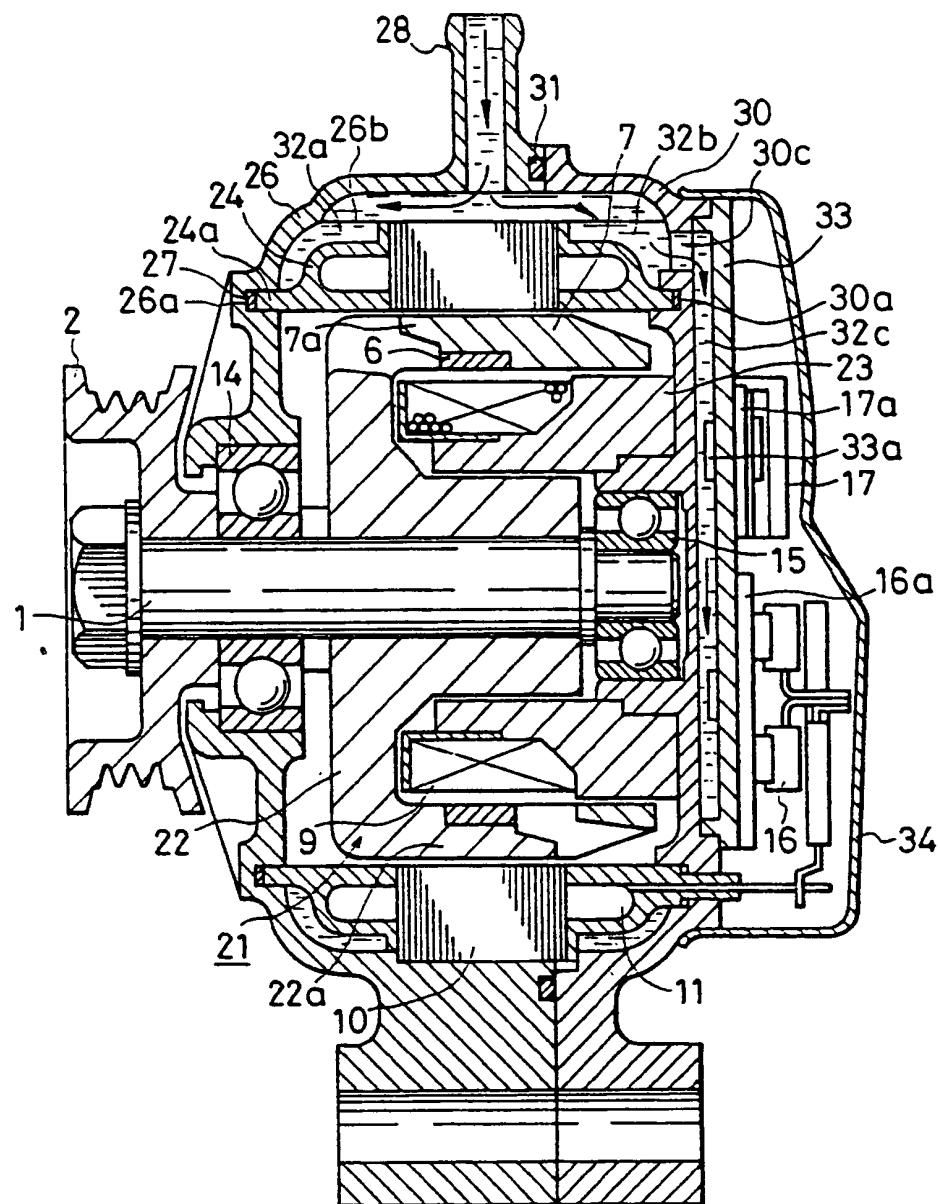


FIG. 6

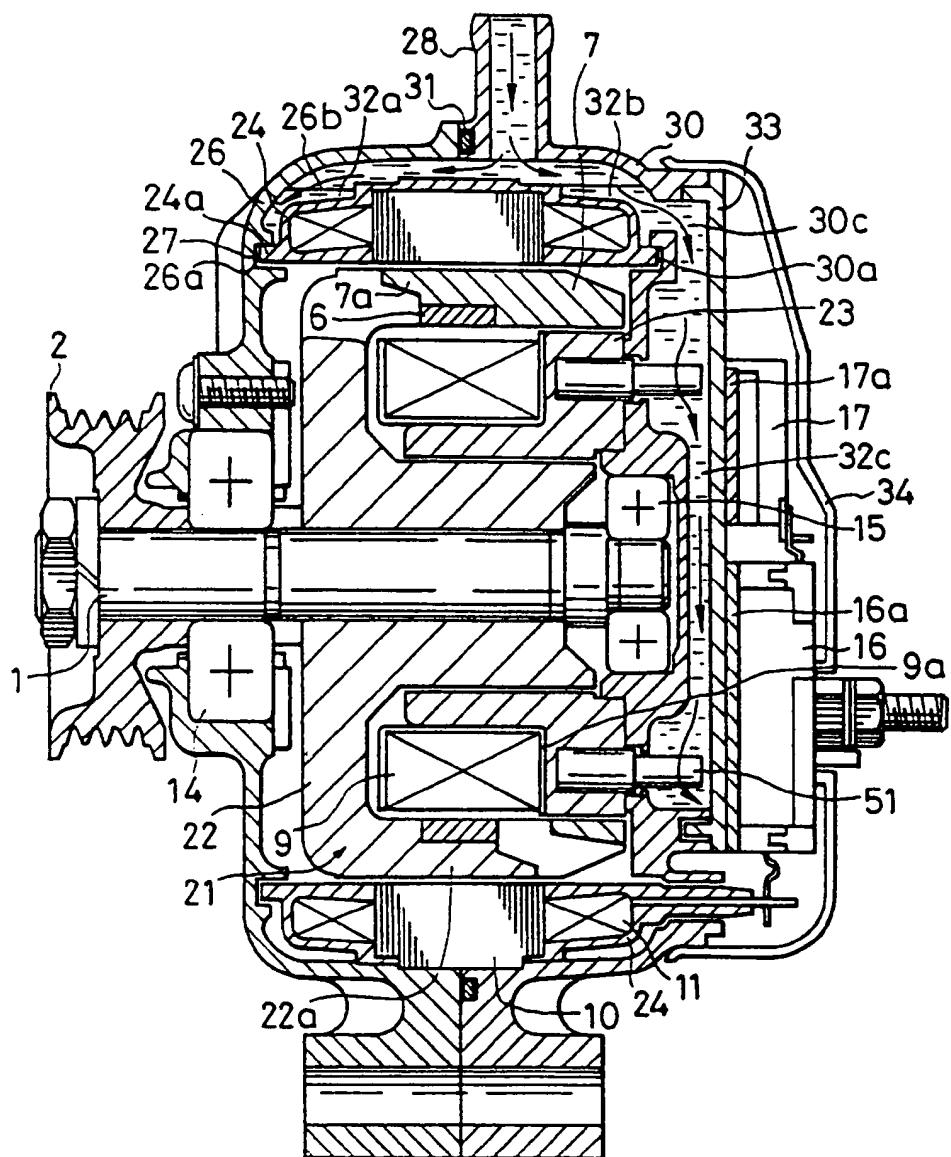


FIG. 7

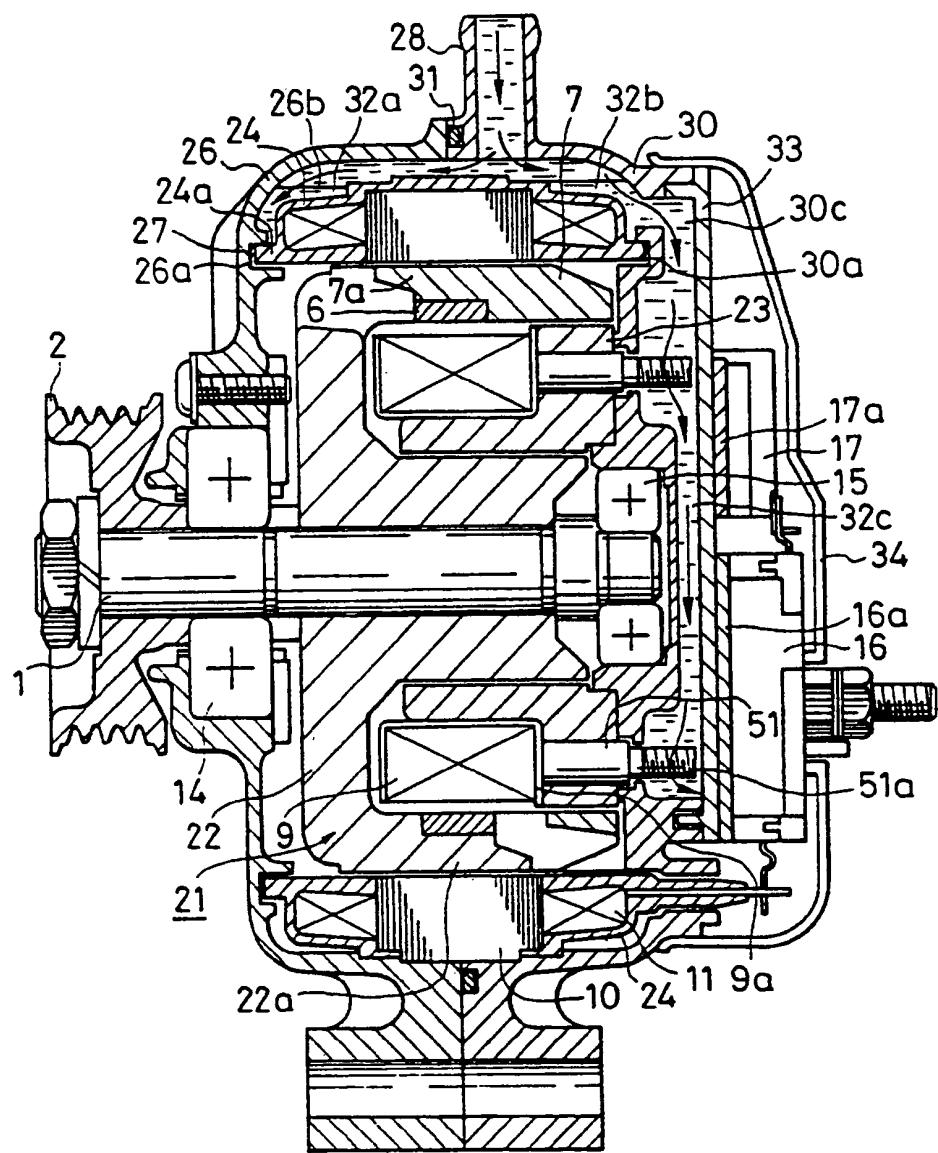


FIG. 8

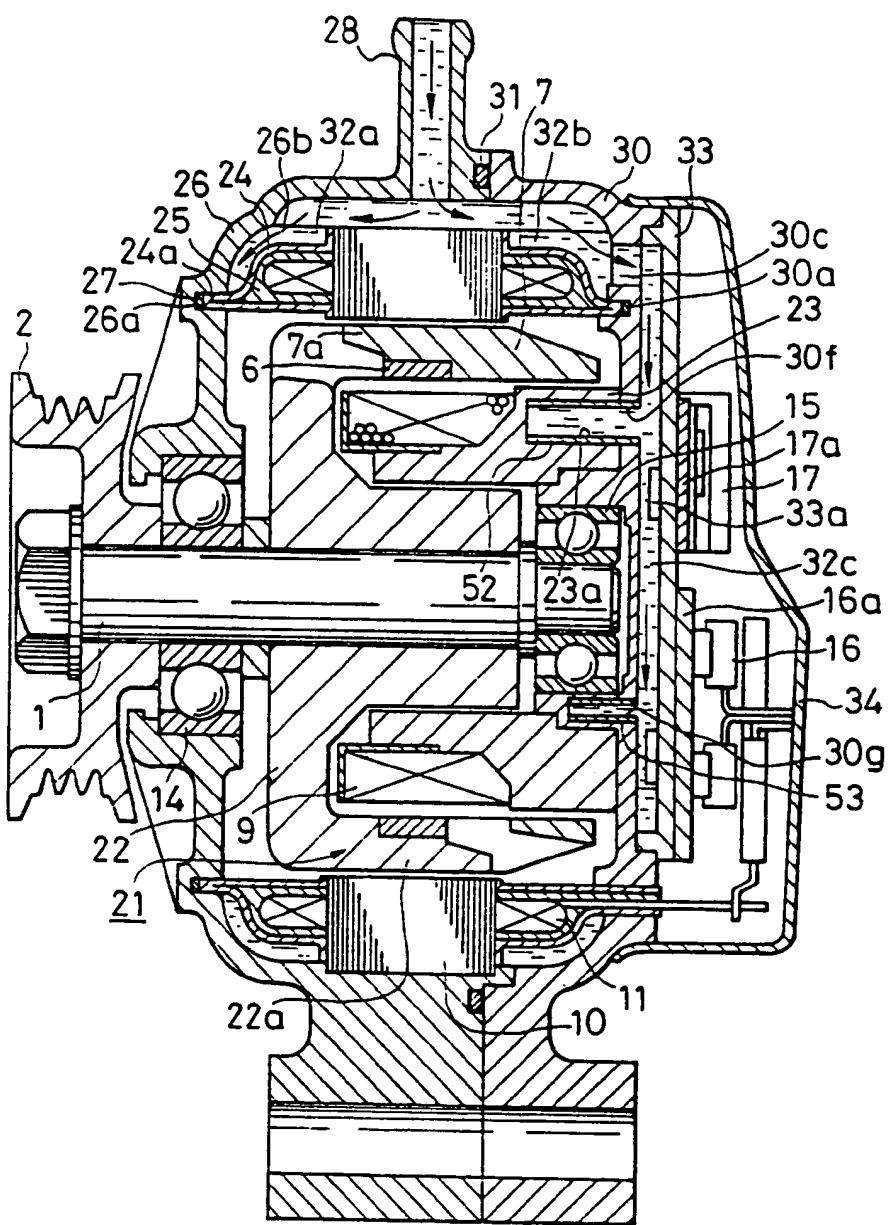


FIG. 9

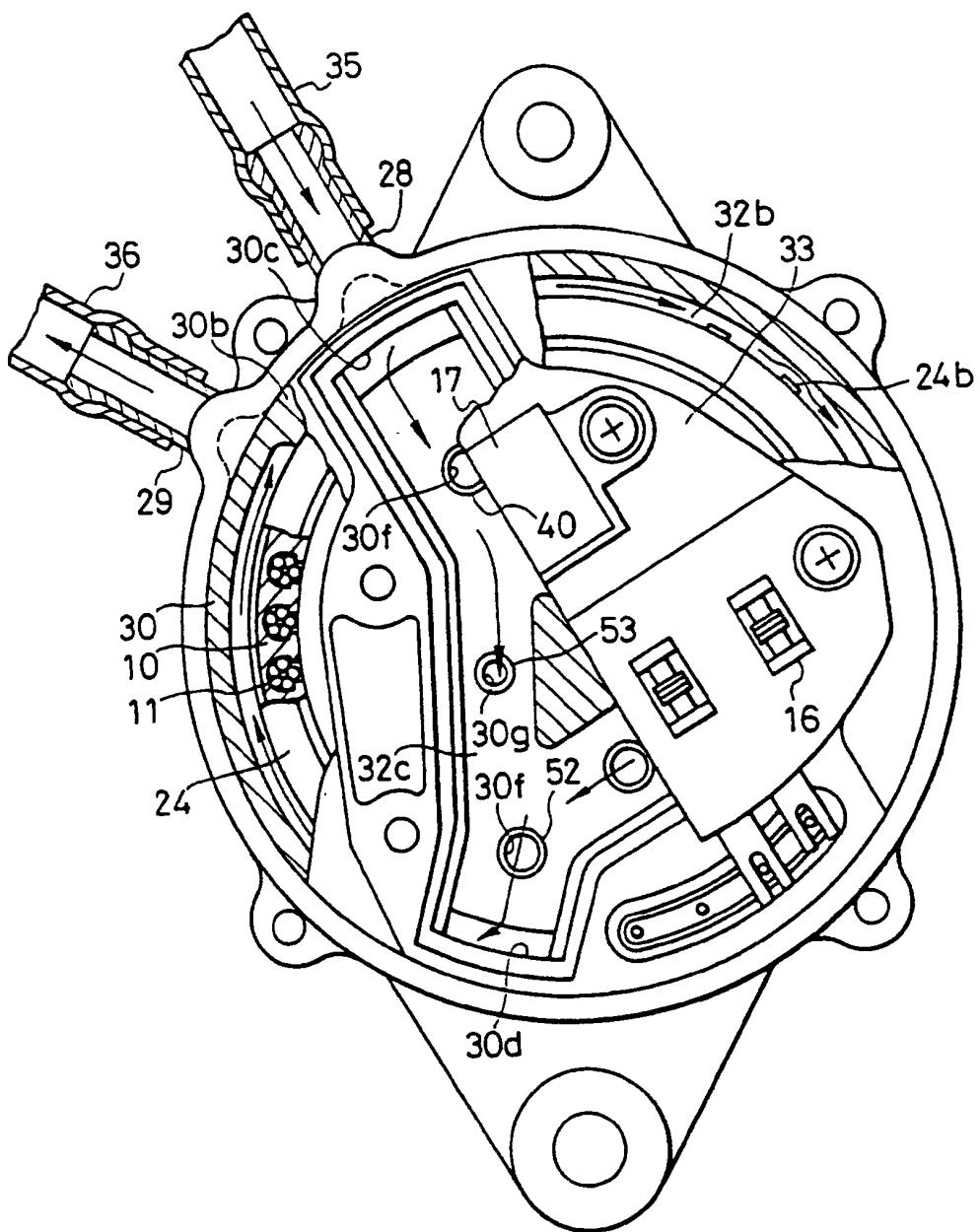


FIG. 10

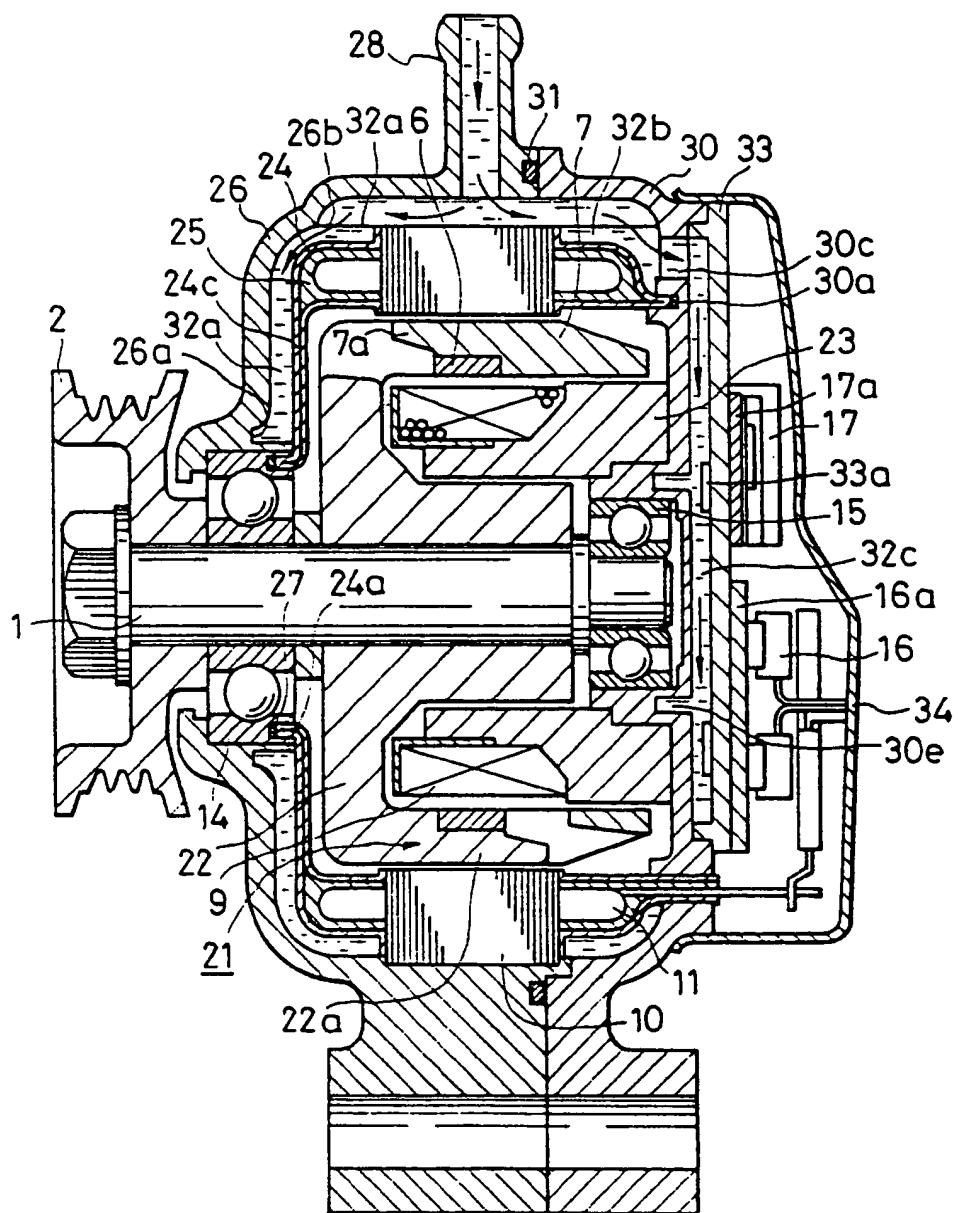


FIG. 11

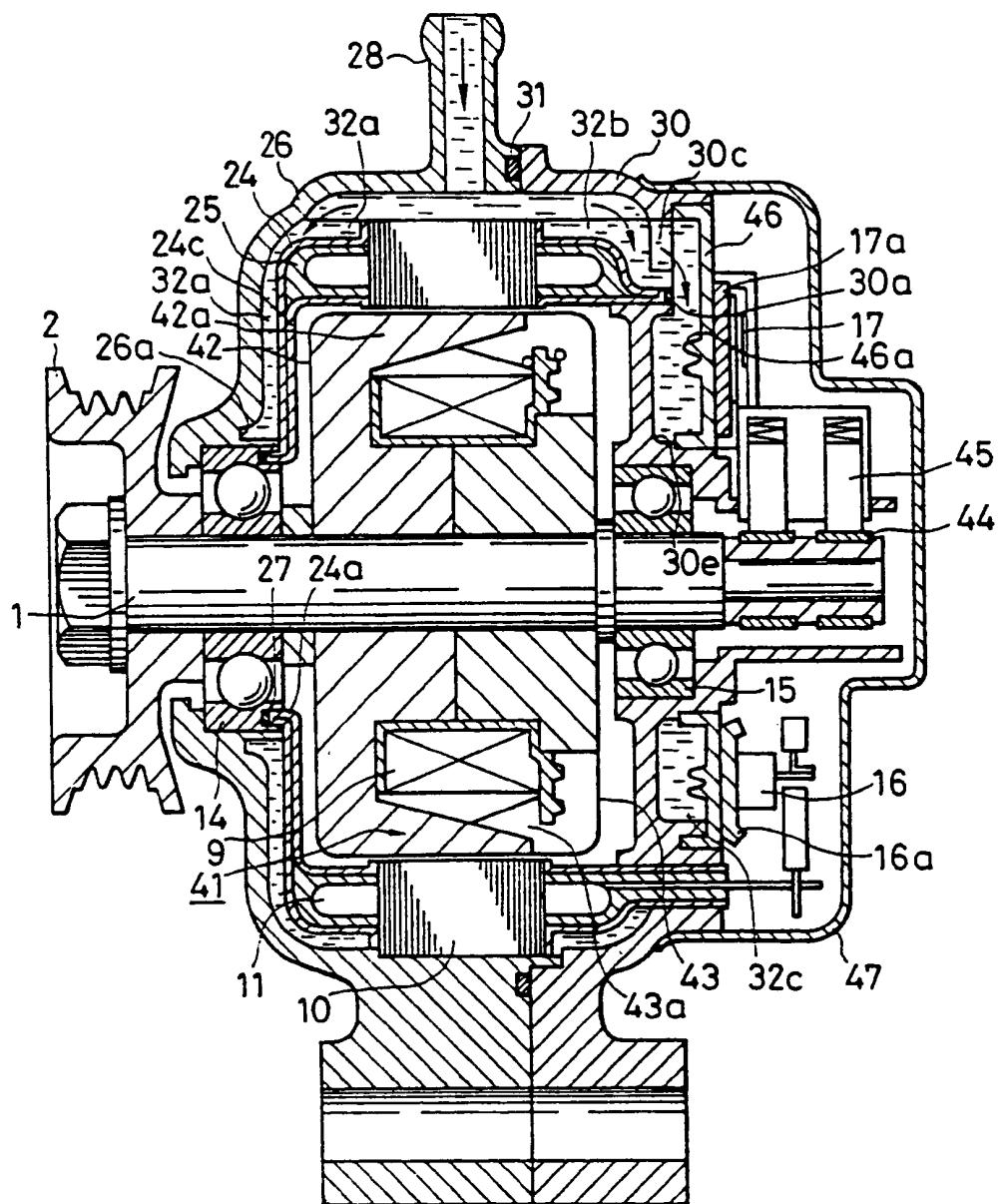


FIG. 12

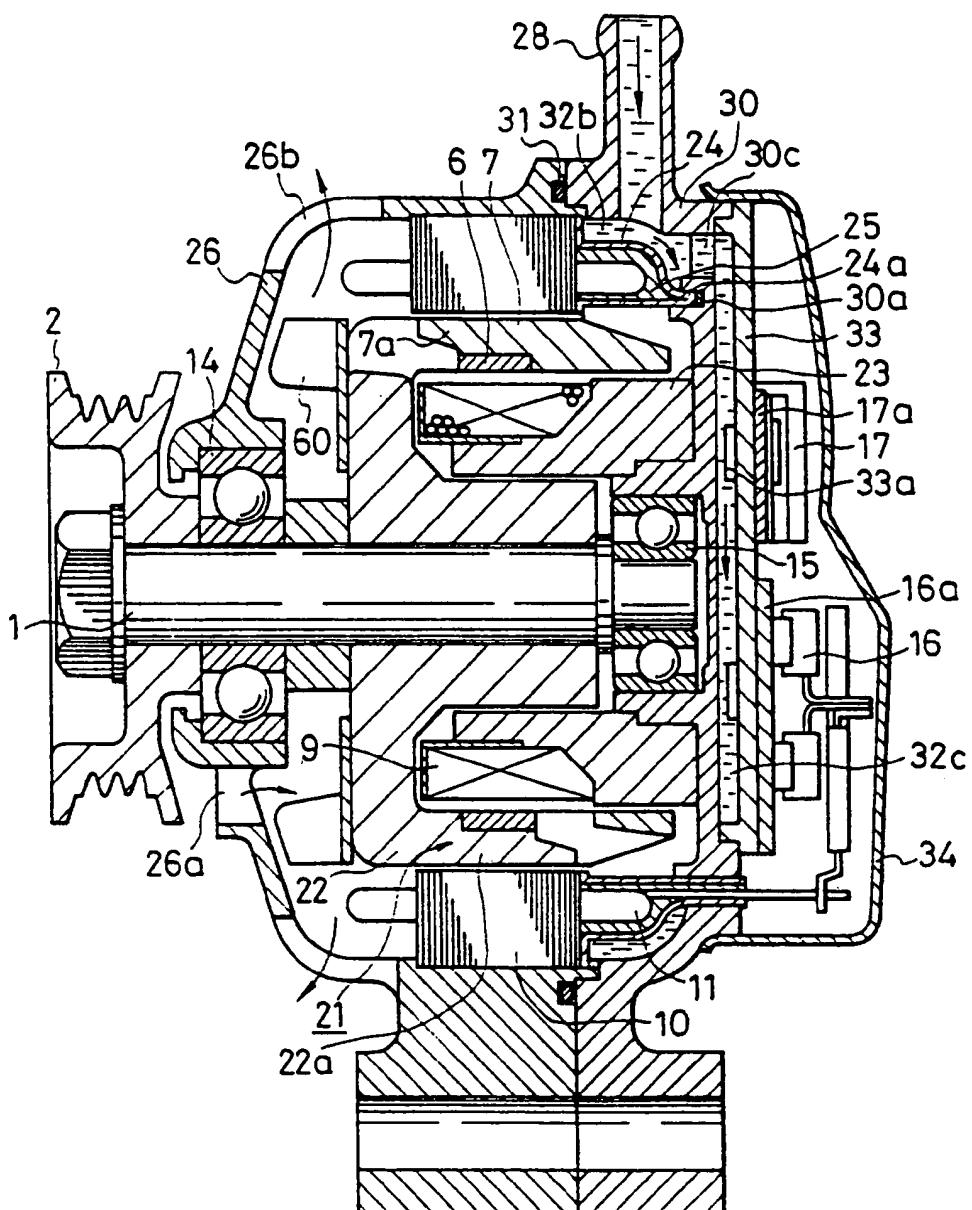


FIG. 13

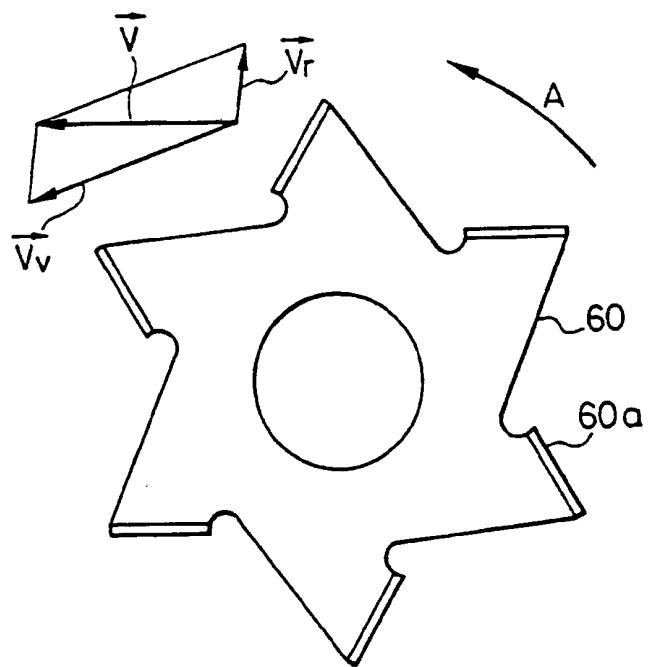


FIG. 14

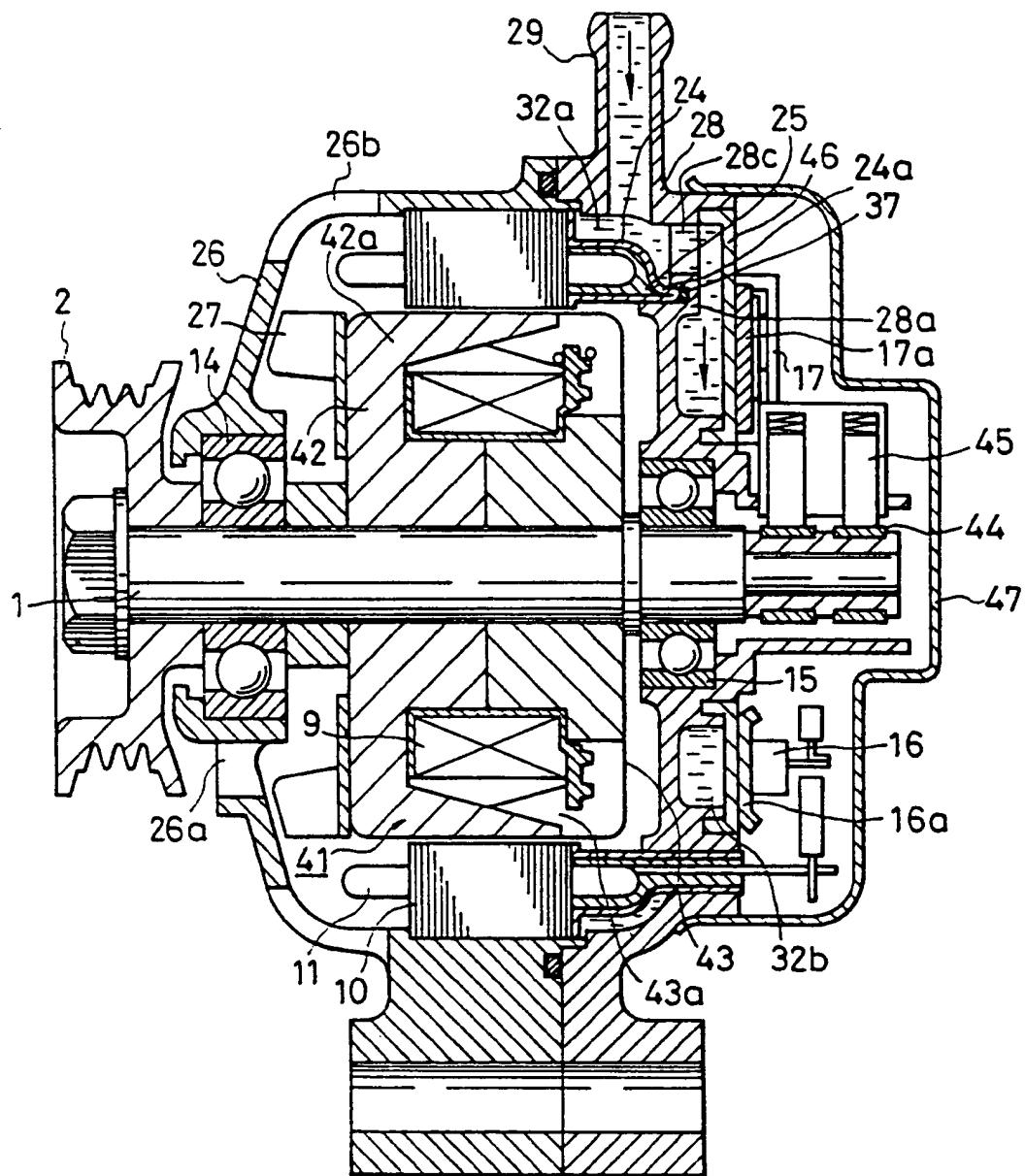


FIG. 15

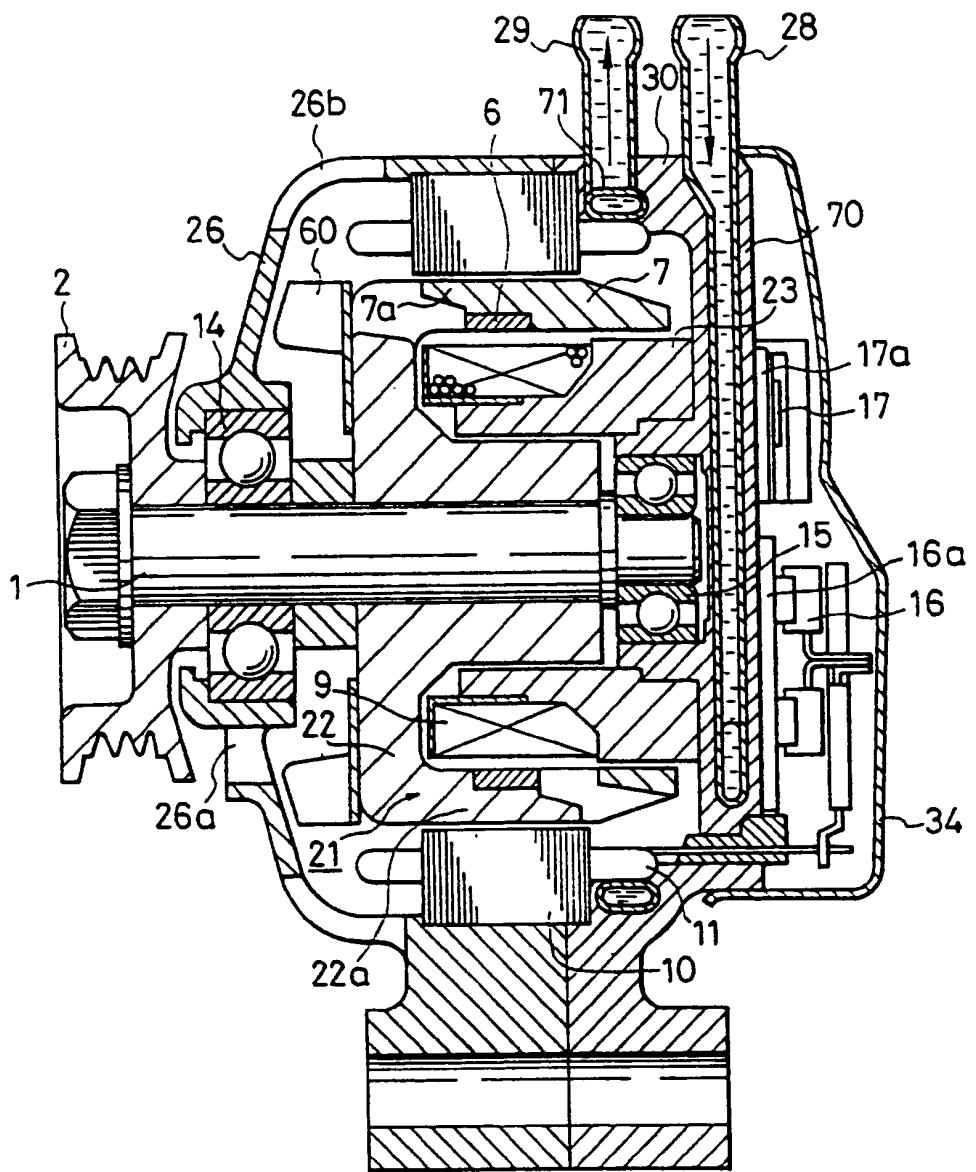
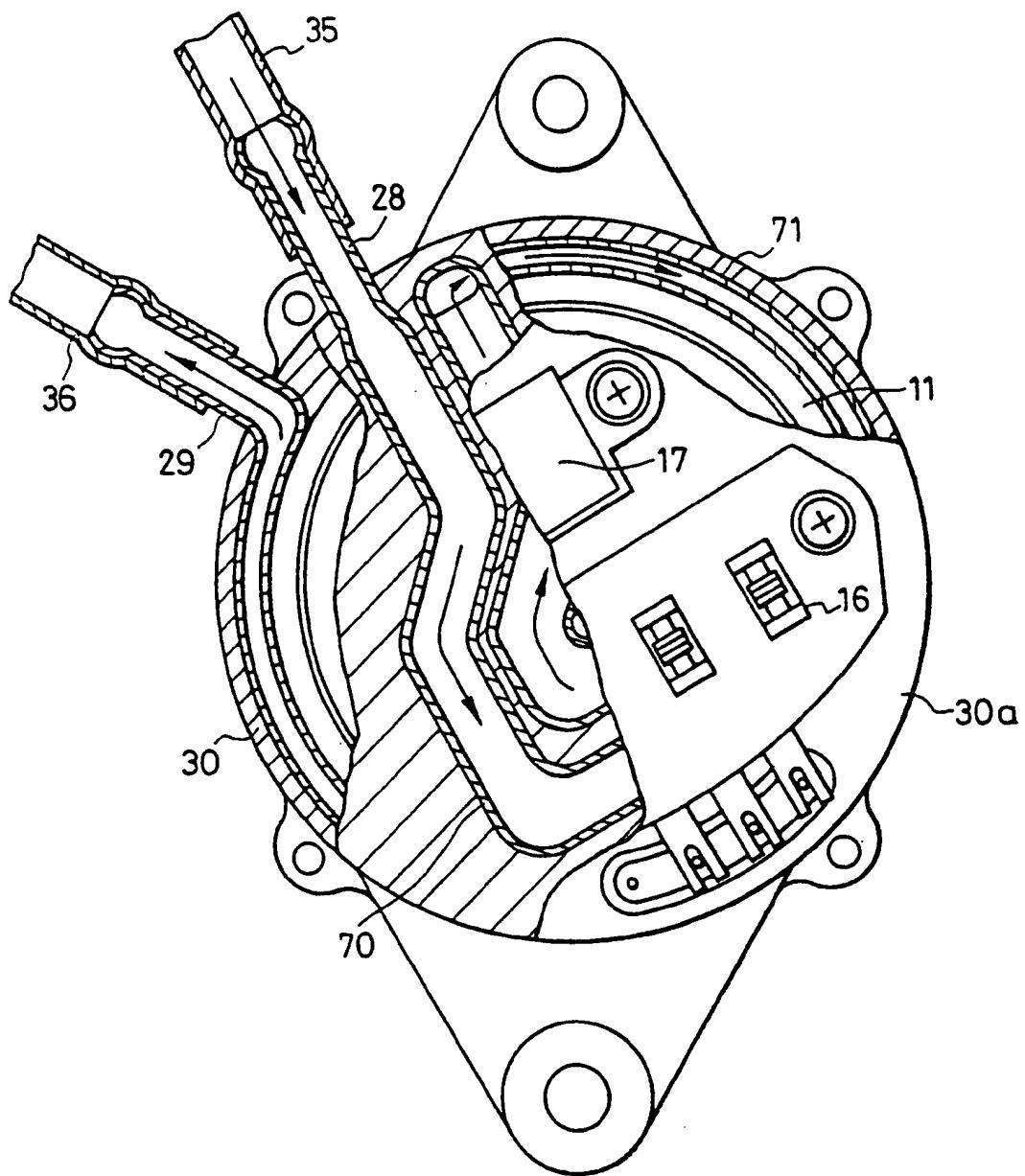


FIG. 16



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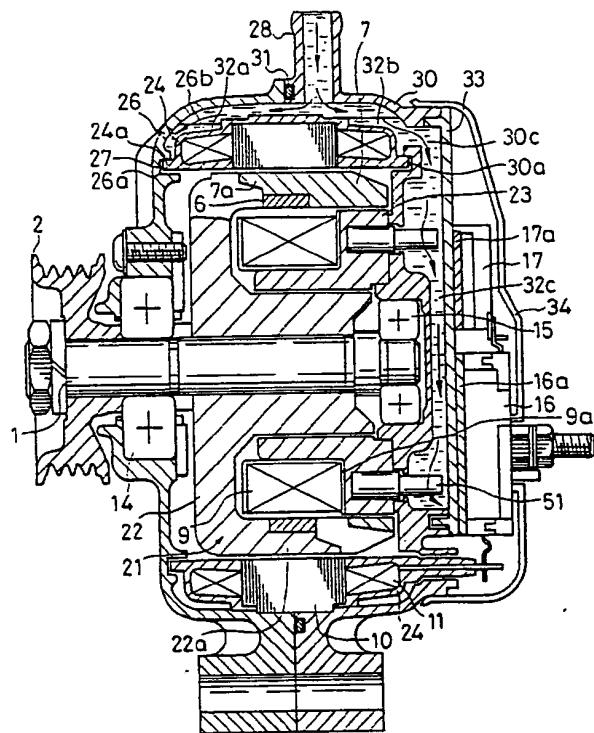
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High thermal conductive members (51) coupled to a stationary core (23) extend therefrom through a rear bracket (30) into the branch coolant passage (32c).

FIG. 6





European Patent  
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# EUROPEAN SEARCH REPORT

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DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.4)
Y	GB-A-2 117 187 (ROBERT BOSCH GMBH) * page 1, line 77 - line 121; figure 1 *	5	H02K9/197 H02K9/22 H02K19/22 H02K19/36 H02K11/00
Y	--- EP-A-0 049 735 (ROBERT BOSCH GMBH) * page 6, line 4 - page 9, line 22; figures 1,4 *	5	
A	--- US-A-4 221 982 (L.J.RAVER & AL.) * column 2, line 33 - line 37 * * column 7, line 34 - line 48; figure 5 *	1,5	
A	--- DE-U-7 012 107 (LICENTIA PATENT-VERWALTUNGS-GMBH ) * page 5, line 12 - line 15; figure *	1,5	
A	--- DE-A-2 828 473 (ROBERT BOSCH) * page 8, line 14 - line 17; figure 3 *	1,5	
A	--- CH-A-403 960 (BROWN,BOVERI & CIE) * page 2, line 33 - line 36; figure 3 *	1	
A	--- PATENT ABSTRACTS OF JAPAN vol. 6, no. 200 (E-135)(1078) 9 October 1982 & JP-A-57 110 044 ( TOKYO SHIBAURA DENKI K. K. ) 8 July 1982 * abstract *	1	TECHNICAL FIELDS SEARCHED (Int. Cl.4)
	-----		H02K
<p>The present search report has been drawn up for all claims</p>			
Place of search	Date of completion of the search	Examiner	
BERLIN	04 MARCH 1992	LEOUFFRE M.	
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons ..... & : member of the same patent family, corresponding document	
X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document			

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